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博 士 学 位 论 文

基于典型红树植物群落的红树林软体动物
生态研究

Ecological Studies on Mangrove Molluscs based on Typical
Mangrove Communities

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摘要

本文基于典型红树植物群落,对中国大陆红树林软体动物的种类和数量组成进行较长时间、连续和同步的多尺度定量和定性研究。于 2007 年 4 月至 2010 年 1 月,选取海南(东寨港、文昌清澜港、万宁石梅湾)、广东(湛江特呈岛、廉江高桥)、广西(防城港)和福建(九龙江口)13 个有代表性的红树植物群落,开展软体动物季节性定量和定性调查,其中海南东寨港、广东湛江特呈岛和廉江高桥 3 个地点(共 7 个红树植物群落)的调查时间持续 3 年,其余地点除万宁石梅湾(持续 5 个季度)外,均持续 9 个季度。此外,于 2008 年 11 月和 2009 年 6 月至 9 月,分别对海南三亚、浙江乐清西门岛、广东深圳坝光和雷州半岛的红树林分布区开展软体动物定性调查,从而初步查清中国大陆红树林区软体动物种类多样性和分布格局,尤其是典型红树植物群落中软体动物的分布特征和季节变化,同时分析寒害对红树林软体动物的影响及其响应和恢复过程,并进一步评估红树林软体动物生存状况,为红树林生态系统的保护、恢复和管理提供科学依据。主要研究结果如下:

(1) 中国大陆红树林区共有软体动物 529 种,隶属于 5 纲 22 目 104 科,以双壳纲(259 种)和腹足纲(253 种)的种类为主,共占总种数的 96.79%,而生态型以底上型(252 种)和底内型(199 种)为主。其中实地采集记录 493 种(隶属于 5 纲 21 目 100 科),包括 1 个新种(蛋挞锥滨螺 *Mainwaringia dantaee* Fang, Peng, Zhang *et* He, n. sp.)以及 81 个中国大陆红树林区新记录种。各省红树林区分布的软体动物种数为广东(98 科 403 种)>海南(90 科 367 种)>广西(58 科 173 种)>福建(60 科 140 种)>浙江(25 科 40 种)。由于大规模的海堤建设、经济发展和环境变迁,中国大陆红树林区软体动物的生存现状令人堪忧。

(2) 作为红树林软体动物的特殊类群,耳螺对环境变迁和人为干扰的影响很敏感,可作为修建海堤等工程对红树林生态系统影响的重要指示物种。中国大陆红树林区共有耳螺 9 属 34 种,其中实地采集记录 9 属 26 种,包括 21 种新记录种。除少数种类如中国耳螺(*Ellobium chinense*)、米氏耳螺(*Ellobium aurismidae*)和核冠耳螺(*Cassidula nucleus*)为广布种外,其他均为窄布种甚至

高度窄布种。随着纬度的降低,耳螺的种数不断增加,各省红树林区的分布情况为海南(19种)>广东(15种)>广西(12种)>福建(9种)>浙江(1种)。

(3) 2008年1月,我国南方等地19个省遭受50年一遇的持续低温天气。寒害对广东廉江高桥红海榄(*Rhizophora stylosa*)群落中软体动物的群落结构和组成有持续而显著的影响。与2007年春季(4月)的数据相比,2008年春季(4月)树栖型软体动物的栖息密度、生物量、种数和物种丰富度分别减少了87.5%、85.1%、50.0%和37.7%,而地栖型软体动物的生物量、种数和物种丰富度分别减少了76.2%、62.5%和100%,但其栖息密度却增加了47.5%。

(4) 寒害后广东廉江高桥红海榄群落中软体动物的恢复过程缓慢,至少需要3年时间,树栖型软体动物较地栖型所需的恢复时间更长。与2007年10月(寒害前1个季度)的数据相比,2009年10月(寒害后2年)树栖型软体动物的栖息密度、生物量、种数和物种丰富度分别减少了26.3%、8.4%、32.4%和15.0%,而地栖型软体动物的生物量、种数和物种丰富度分别减少了17.9%、20.0%和9.9%,但其栖息密度却增加了7.4%。

(5) 不同红树植物群落的软体动物种数有很大差别,其中水椰(*Nypa fruticans*)、秋茄(*Kandelia candel*)、角果木(*Ceriops tagal*)、海莲(*Bruguiera sexangula*)和桐花树(*Aegiceras corniculatum*)群落明显较白骨壤(*Avicennia marina*)、红海榄、木榄(*Bruguiera gymnorhiza*)和杯萼海桑(*Sonneratia alba*)群落少。底质是影响红树林地栖型双壳纲软体动物分布和栖息密度的制约因子,适宜程度为沙泥质>泥沙质>泥质/沙质。东寨港海莲群落、角果木群落、浮宫秋茄群落、万宁水椰群落和红寨桐花树群落不仅软体动物种数少,而且均无地栖型双壳类,这些群落的底质为泥质或沙质。

(6) 红树植物群落是影响不同红树植物群落间软体动物物种相似度的主要因子。同一个分布区的不同红树植物群落,其软体动物物种相似度高。此外,不同分布区的相同或相似群落特征的红树植物群落间的软体动物相似度较高。在所有的红树植物群落中,万宁水椰群落与其他群落的软体动物相似度最低,平均相似度指数仅为20.62%。

(7) 红树植物群落是影响树栖型软体动物数量组成(栖息密度和生物量)的制约因子。树栖型软体动物数量组成(栖息密度和生物量)在不同的红树植物

群落中的大致规律是：白骨壤群落>桐花树群落>杯萼海桑群落>红海榄群落/木榄群落>秋茄群落/角果木群落/水椰群落>海莲群落。当地栖型软体动物优势种中无双壳类时，红树植物群落的群落特征是影响地栖型软体动物数量组成的主要因子。

（8）不同红树植物群落中软体动物的季节变化规律并不一致，但一般夏季和秋季大于冬季，体现为：秋季>夏季>春季>冬季，或夏季>秋季>春季>冬季。由于受寒害影响，有些群落的软体动物季节变化曲线波动很大，没有规律或与原有规律不符。伴随着全球气候变化，寒害等极端天气事件已愈发普遍，因此，研究软体动物的季节变化应至少跟踪 3 年时间。

（9）红树林区树栖型软体动物和地栖型软体动物无论在种类组成、数量组成、季节变化、受寒害的影响及其响应和恢复过程等方面，均有很大差异。因此，在野外调查和研究工作中，应将两者区分并独立开展研究。

关键词：软体动物；红树植物群落；季节变化；寒害；多样性

Abstract

A long-term continuous and synchronous research on the species and quantity of mangrove molluscs based on typical mangrove communities was studied in China mainland by both quantitative and qualitative methods in multiple scales. 13 representative mangrove communities of Hainan (Dongzhaigang, Qinglangang of Wenchang, and Shimei Gulf of Wanning), Guangdong (Techeng Island of Zhanjiang, Gaoqiao of Lianjiang), Guangxi (Fangchenggang) and Fujian (Jiulongjiang Estuary) provinces were selected to carry out a seasonal study on mangrove molluscs from Apr 2007 to Jan 2010. Among those sites, the study period in Dongzhaigang of Hainan province, Zhanjiang Techeng Island and Lianjiang Gaoqiao of Guangdong province (with 7 mangrove communities) were lasted for 3 years (with 12 seasonal researches) while at other sites were lasted for 9 seasons except for Shimei Gulf of Wanning (with 5 seasonal researches). Besides, some qualitative studies on molluscs at mangrove areas of Sanya (Hainan province), Yueqing Ximen Island (Zhejiang province), Shenzhen Baguang (Guangdong province) and Leizhou Peninsula (Guangdong province) were carried out in Nov 2008 and from Jun. to Sep of 2009. This study was to find out the species diversity and distribution pattern of molluscs at mangrove areas of China mainland, especially to find out the distribution characteristics and seasonal variations of molluscs at typical mangrove communities. At the same time, the impact of chilling damage upon molluscs and their response and the resuming process were evaluated. Furthermore, this study would evaluate the existence of mangrove molluscs in order to provide scientific evidence for the conservation and management of mangrove ecosystems.

(1) There were 529 molluscs species which belonging to 5 classes, 22 orders and 104 families in mangrove areas in China mainland. Among them, Bivalvia (259 species) and Gastropoda (253 species) took up 96.79% of total species while in terms of ecotypes, epifaunal (252 species) and infaunal (199 species) outnumbered. 493

species (5 classes, 21 orders and 100 families) have been collected in the fields, among which including 1 new species (*Mainwaringia dantaae* Fang, Peng, Zhang *et* He, n. sp.) and 81 newly-recorded species in mangrove areas of China mainland. The molluscs species number in different provinces was Guangdong (98 families, 403 species) > Hainan (90 families, 367 species) > Guangxi (58 families, 173 species) > Fujian (60 families, 140 species) > Zhejiang (25 families, 40 species). With the massive seawall construction, economic development and environmental changes, the existence of mangrove molluscs in China mainland was causing concerns.

(2) Ellobiid, as a special group of mangrove molluscs, can be used as an indicator species for the impact of seawall construction on mangrove ecosystems because of the sensibility to environmental change and human interference. There were 34 ellobiid species belonging to 9 genus in mangrove areas of China mainland, among which 26 species from 9 genus were collected in the fields including 21 newly-recorded species. Most ellobiid species were narrowly and even highly-narrowly distributed except for *Ellobium chinense*, *Ellobium aurismidae* and *Cassidula nucleus* which were widely distributed. With the decrease of latitude, the species number of ellobiid was increased. The ellobiid species number in different provinces is Hainan (19 species) > Guangdong (15 species) > Guangxi (12 species) > Fujian (9 species) > Zhejiang (1 species).

(3) Infrequent continuous low temperatures of a fifty-year return period occurred in Southern China in January, 2008. The effects of chilling on the structure and constitution of molluscs at *Rhizophora stylosa* forest of Guangdong Lianjiang Gaoqiao were prominent, continuous and significant. Compared with Apr 2007, the density of the arboreal molluscs decreased by 87.5% in Apr 2008, while the benthic molluscs increased by 47.5%; the biomass in Apr 2008 of the arboreal type and the benthic type decreased by 85.1% and 76.2%, respectively; the species number in Apr 2008 of the two types decreased by 50.0% and 62.5%, respectively; and the species richness in Apr 2008 of which decreased by 37.7% and 100% respectively.

(4) The resuming process of molluscs at *Rhizophora stylosa* forest of Guangdong Lianjiang Gaoqiao after chilling damage was slow and would last 3 years at least.

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